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UGANDA

TECHNICAL ASSISTANCE REPORT—IMPROVING GDP FORECASTING

September 2017

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Uganda

Improving GDP Forecasting

Fazeer Sheik Rahim and Anne Epaulard

Technical Assistance Report | June 2014

INTERNATIONAL MONETARY FUND

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Building macroeconomic capacity in East Africa

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ABBREVIATIONS AND ACRONYMS

AFE	IMF East Africa Regional Technical Assistance Center (East AFRITAC)
AIC	Akaike Information Criterion
ARIMA	Autoregressive Moving Average
BIC	Bayesian Information Criterion
BoU	Bank of Uganda
CIEA	Composite Indicators of Economic Activity
FAD	Fiscal Affairs Department
FY	Fiscal Year
GDP	Gross Domestic Product
GFSM	Government Finance Statistics Manual
ILO	International Labor Organization
IMF	International Monetary Fund
MoFPED	Ministry of Finance, Planning, and Economic Development
MPD	Macroeconomic Policy Department
NA	National Accounts
ODI	Overseas Development Institute
OECD	Organization for Economic Cooperation and Development
PCFS	Private Capital Flows Survey
PFM	Public Financial Management
QGDP	Quarterly Gross Domestic Product
TFP	Total Factor Productivity
UBoS	Uganda Bureau of Statistics
URA	Uganda Revenue Authority
WEO	World Economic Outlook

PREFACE

In response to a request from the Director of the Macroeconomic Policy Department (MPD) of the Ministry of Finance, Planning and Economic Development (MoFPED), an East AFRITAC (AFE) mission visited Kampala during the period March 31–April 9, 2014. The mission was to assist staff of the MPD to assess and improve their capacity in macroeconomic forecasting, notably in forecasting quarterly and annual GDP.

The mission comprised of Mr. Fazeer Sheik Rahim (Macro-Fiscal Advisor) and Ms. Anne Epaulard (consultant). It was undertaken within the context of the project: "*Uganda: Improving GDP forecasting.*"

The mission met with relevant staff from the Ministry of Finance, Planning and Economic Development. It wishes to express its sincere appreciation to Mr. Laurence Kiiza, Director Economic Affairs, Mr. Robert Okudi, Commissioner, Macroeconomic Policy Department and also to their staff, for the cooperation and hospitality extended to the mission. The mission wishes to express its gratitude to the various representatives of donor agencies met during the course of the mission for their insights that have helped in the writing up of this report.

EXECUTIVE SUMMARY

Background

MoFPED is responsible for producing baseline macro-fiscal forecasts to develop the medium-term fiscal framework in support of the annual budgetary exercise and to monitor in-year fiscal developments. To enhance the credibility of the budget and avoid frequent in-year budget adjustments, the authorities are keen to improve the quality of revenue forecasts.

Notwithstanding improvements in revenue forecasting since 2012, several issues have been identified by previous AFE missions regarding annual GDP forecasts and the published estimates of quarterly GDP, on which revenue forecasts are based. These include errors in the estimates of some sectors of activity, and inadequate seasonal adjustments.

The mission

To ensure the consistency among the various forecasting tools available to the authorities, this mission revised and updated existing tools and provided several techniques that can be used to compare and reconcile GDP forecasts from different sources and for different time horizons.

Main conclusions

The mission identified some gaps in the forecasting framework and provided the tools to address these gaps. These gaps include the absence of forecasts of potential GDP, the insufficient use of short-term GDP forecasting and nowcasting tools and of Quarterly GDP (QGDP) releases to project annual GDP growth, and the lack of analysis of past forecasting errors. The mission provided robust approaches to the calculation of potential GDP, to incorporate QGDP releases in annual GDP forecasts, to nowcast and forecast QGDP using ARIMA modeling and Indicators of Economic Activity, and to take stock of past forecast errors.

Recommendations

The main recommendation is to improve GDP forecasting, ranging from a quarterly to a five-year horizon, using the tools that are now available at MoFPED. The five-year forecast can be fruitfully used in the medium-term projections of government revenue, deficit and debt. The short-term forecasts should be systematically integrated within the (annual) sectoral forecasts currently being done at the MoFPED.

While considering the set of tools under development (notable the macro-econometric model and the computable general equilibrium model), the mission recommends the deployment of these tools in a more urgent manner, in order to stimulate learning-by-doing of local staff.

I. INTRODUCTION

1. **This is the *Aide-Mémoire* of the IMF - East AFRITAC mission which visited the Ministry of Finance, Planning and Economic Development (MoFPED) of Uganda from March 31–April 9, 2014 to build capacity in forecasting GDP.** To assist the authorities, this aide-memoire contains an executive summary. It is organized as follows: section II provides background information, section III gives an overview of work undertaken during the mission, section IV summarizes the main results and section V provides a summary of the next steps required to improve GDP forecasting capacity and monitoring the effectiveness of current methodologies with a view to guide policy making. The annexes summarize the main methodologies used during the mission.

II. BACKGROUND

2. **MoFPED is responsible for producing baseline macro-fiscal forecasts to develop the medium-term fiscal framework in support of the annual budgetary exercise and to monitor in-year fiscal developments.** To enhance the credibility of the budget and avoid frequent in-year budget adjustments, the authorities are keen to improve the quality of revenue forecasts, including quarterly cash flows.

3. **Notwithstanding improvements in revenue forecasting since 2012, several issues have been identified by previous AFE missions regarding annual GDP forecasts and the published estimates of quarterly GDP, on which revenue forecasts are based.** These include errors in the estimates of some sectors of activity, and inadequate seasonal adjustments. The last AFE mission in March 2013 provided a statistical approach to improve the quarterly GDP estimates and forecasts using ARIMA modeling.

4. **To ensure the consistency among the various forecasting tools available to the authorities, this mission revised and updated existing tools and provided several techniques that can be used to compare and reconcile GDP forecasts from different sources and for different time horizons.**

III. WORK UNDERTAKEN DURING THE MISSION

5. **Although the authorities possess three main forecasting tools for GDP in the form of a macro-econometric model, a time-series model and a sectoral tool, it uses only the latter.** The sectoral tool consists of aggregating forecasts for the main sectors of sectors of economic activity into an aggregate GDP forecast. These forecasts by economic activity are generated using surveys of businesses and line ministries.

6. The mission identified some gaps in the forecasting process and provided the tools to address these gaps. These gaps are as follows:

a. No analytical method was used to forecast potential GDP, which was assumed to be equal to 7%, even though actual growth has been lower than since fiscal year 2009/10.

b. Quarterly GDP releases were not being systematically included in the re-evaluation of annual GDP forecasts.

c. A time-series tool developed with the help of AFE last year was not being used for quarterly GDP forecasting.

d. Given that QGDP is released with a four-month lag, there was little analytical work being done at MoFPED to understand the business cycle and, by extension, its implications on government revenue and spending.

e. There was little or no analysis of the forecast errors of the sectoral forecasting tools being used.

7. The following was undertaken to address these gaps:

a. A simple and yet robust approach to calculating potential GDP, using the production function approach, was explained to the forecasting team.

b. The concept of growth carry-overs from quarterly to annual GDP was explained to the same team. This concept allows the forecaster to incorporate existing information on quarterly GDP growth into her forecast for annual GDP growth.

c. The tool based on time series, developed last year by an AFE mission, was updated and minor bugs were resolved.

d. Composite Indicators of Economic Activity (CIEAs) were introduced to the forecasting team. Using the CIEA tool and data kindly provided by the Bank of Uganda, the mission showed the usefulness of this tool to nowcast (i.e., forecast current QGDP which will only be released in four months' time).

e. A simple approach on how to take stock of forecast errors was explained.

A. Develop a Production Function Approach to GDP Forecasting

8. A standard production function model was developed to provide growth decomposition in Uganda since 1990. The idea is to broadly quantify the contributions of capital, labor and total factor productivity (TFP) to economic growth. This is done using a production function approach that links the growth rate in GDP to the growth rate of labor and capital, and deduces the growth in TFP as the residual. Annex II explains the methodology used for the calculations.

9. Calculations were done using annual data from the Penn World Table[1], for GDP figures from 1950 to 1983, International Labor Organization[2] (ILO), for labor data, and IMF World Economic Outlook[3] (WEO), for GDP and investment figures from 1984 to 2012. In addition, the share of wages to GDP was assumed to be 0.65, which is a standard assumption. From these data, and assuming a Cobb-Douglas aggregate production function, an estimate of the contribution of TFP to annual growth was calculated.

10. Over the period, the contribution of TFP to economic growth in Uganda was around 2% per year over the period 1990–99. It stayed at this level until mid-2000, and dropped to less than 1% per year on average since 2006. Over the period 1990–2012, the contribution of labor to growth has been constant at around 2% per year. The contribution of capital to economic growth was below 2.3% a year over the period 1990–99, and increased to around 3.2% per year over the period 2000–12. These results are summarized in Annex II.

11. One useful application of this tool is to calculate the growth in TFP required to generate a future growth path, based on some reasonable assumptions on growth in capital and labor. For instance, it can be shown that, if TFP were to continue growing at 1% per year, potential growth would be around 6%. This is lower than the 7% baseline growth assumed in the medium-term fiscal framework for the past two years. Only if TFP were to grow at the higher rate of 2% per year would potential growth reach 7%.

12. The mission felt that this exercise should inform the growth forecasts assumed in the macro-fiscal framework and should have its place in discussions (both internally and with the IMF team) on the drivers of growth. Although the realization of large infrastructural progress, the advancement in regional integration and the discovery of natural resources could be potential candidate explanations behind the relatively optimistic 7% forecasts, the mission argued that an alternative scenario under a 6–6.5% potential growth for the medium term would be worth considering. This argument gains more weight when one considers annual growth in the past three years and the quarterly GDP estimates for FY2013–14, which all point toward annual growth not exceeding 6.5%.

13. For robustness, two different assumptions were made regarding the evolution of the stock of capital. Under the first assumption, the ratio of investment to GDP will stay constant at its 2012 level of 24.2%. Under the second assumption, the investment to GDP ratio will increase uniformly to reach 30% in 2030. Little changes in potential growth are observed, under these alternative assumptions: in the first case, the contribution of capital stock to growth will be 2.9% per year, while, in the second, its contribution will be an annual 3.2% (see Annex I).

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[1] https://pwt.sas.upenn.edu/

[2] http://www.ilo.org/global/statistics-and-databases/lang--en/index.html/

[3] http://www.imf.org/external/data.html/

B. Develop an Approach to Update Annual GDP Forecasts with New Quarterly GDP Releases

14. Since October 2011 the Ugandan Bureau of Statistics publishes quarterly estimates of real GDP. While these estimates of quarterly GDP are used in revising the annual growth forecasts for the current fiscal year in November and in May, this has not been done in a formal way. This amounts to a substantial loss of information, as QGDP releases are highly informative in improving annual forecasts for the current and next fiscal years. While the importance of QGDP on current-year GDP forecasts was well appreciated by all staff met by the mission, the notion of carry-over growth, which is the extent to which growth in QGDP in a current fiscal year impacts growth in annual GDP in the next fiscal year, was not well understood.

15. The mission provided the forecasting team at MoFPED with a simple arithmetic method to systematically incorporate latest real GDP estimates into annual forecast. The transition from quarterly GDP growth to annual GDP growth was not clear to the forecasting team—many thought that annual growth was simply the sum of quarterly growths. A good approximation for *annual* growth rate is, in fact, the weighted average of seven consecutive *quarterly* growth rates:

$$g_t \approx 0.25g_{Q2,t-1} + 0.5g_{Q3,t-1} + 0.75g_{Q4,t-1} + g_{Q1,t} + 0.75g_{Q2,t} + 0.5g_{Q3,t} + 0.25g_{Q4,t}$$

where g_t represents annual growth from year t-1 to 1 and $g_{Qi,t}$ represent quarterly growth from quarter i-1 to i, in a given year t**.**

16. This arithmetic method provides a useful consistency checks between annual growth forecasts and actual quarterly GDP releases. For instance, taking into account the latest releases of quarterly GDP estimates by UBOS (which as of April 2014 was until the second quarter of FY 2013–14), it is possible to calculate that the lowest bound for the growth rate for FY 2013–14 is 5.9% (i.e., assuming that growth for the last two quarters of FY 2013–14 would be zero). This is higher than the most recent (November 2013) growth forecast of 5.7%. There is clearly a case here for revising annual growth forecasts in light of new QGDP releases.

17. With this method, the growth carry-over from one year to the next one can also be calculated. The growth carry-over is the growth rate for a given year that comes exclusively from the quarterly growths generated in the previous year. From the previous formula, we have

$$carryover\ g_t \approx 0.25g_{Q2,t-1} + 0.5g_{Q3,t-1} + 0.75g_{Q4,t-1}$$

Thus, growth carry-over for FY 2014–15 is currently 0.3%. This means that, in the absence of any quarterly growth in FY2014–15, and in the last two quarters of FY2013–14, which are yet to be published, the Ugandan economy will still grow by 0.3%. For a 1% quarterly growth during the last quarters of FY 2013–14, carry-over growth is 1.5% for FY 2014–15.

C. Update of Previously-Developed Autoregressive Moving Average Forecasting Model

18. In March 2013, an East AFRITAC mission to Uganda developed a tool providing estimates for quarterly nominal GDP, and quarterly forecasts for real and nominal quarterly GDP. The forecast is based on ARIMA processes estimated at the sectorial level. 23 different sectors are considered and estimations can be run on both nominal and real data. The tool selects an appropriate ARIMA model for each sector based on the AIC and BIC statistical criteria. Based on these sectorial models, the tool provides an estimate for growth in each sector for the 10 quarters ahead. The GDP forecast is then obtained by summing up forecast for the activity in the 23 different sectors.

19. Due to some minor bugs within the spreadsheet, the macroeconomic team could not use the tool after having updated it with new data. Working with the macroeconomic team, the mission solved these errors. The tool can be updated with quarterly data provided by UBOS and used to provide forecasts for quarterly and annual growth for both the current and the subsequent fiscal year.

20. An important characteristic of this tool is that it can be used after every quarterly GDP release to provide an updated forecast on quarterly GDP for next four quarters. **Table 1** below summarizes the annual forecasts that the tool would have provided, using available data. For instance, in April 2012, the forecast for FY 2012–13 was 4.9%. In October 2012 and April 2013, the forecasts were revised to 5.8% and 6.3% respectively. The final outturn was 5.8%.

Table 1. Uganda: Autoregressive Moving Average-Based Annual Forecasts for Real GDP

(Annual growth in percentage)

Fiscal year	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	*Mean absolute error*
April (t-1)	6.8	4.9	4.9	n.a.	4.9	6.3	6.1	*1.05*
October (t)	4.8	6.4	4.9	n.a.	5.8	5.5		*1.2*
April (t)	6.0	6.6	n.a.	2.7	6.3	6.0		*0.8*
Outturn	7.3	5.9	6.7	3.4	5.8			

21. Given the frequency at which this tool can provide forecast updates (four times a year, at each QGDP release), it can play an important role during the period November – April, during which the GDP forecasts become critical to budget formulation for the following year. As of April 2014, the latest GDP forecasts for 2013–14 and 2014–15 date back to November 2013. The forecast for 2013–14 is 5.7%, which, if one trusts the quarterly GDP figures released in the meanwhile, will necessitate negative growth rates for the last two quarters of 2013–14. The ARIMA forecasting tool, on the other hand, provides a more realistic forecast of 6.1% for 2013–14. Clearly, there is an added benefit to using the ARIMA approach.

22. The accuracy of the ARIMA tool is not as high as that of the sectoral tool, as shown by the high mean absolute errors (see Table 3). However, it is worth noting that, given the relatively short time series available, the accuracy is likely to improve over time, based on the premise that such statistical models tend to perform better with longer time series. However, this is not necessarily true if there are statistical breaks in the series in the future, which can come from structural changes in the economy.

D. Using Composite Indicators to Nowcast Quarterly GDP

23. The use of composite indicators to have a better grip on the dynamics of QGDP has been adopted by a number of countries in East Africa in recent years. AFE has supported ther National Bank of Rwanda, the Bank of Uganda, the Central Bank of Kenya and the Bank of Tanzania to develop composite indicators of economic activity (CIEA) based on the US Conference Board methodology. Annex IV provides some background information on CIEAs, including the 10-step approach recommended by the Organization for Economic Cooperation and Development (OECD) and a comparison of the different methodologies.

24. The mission worked with the forecasting team on a CIEA model, following the OECD ten-step approach. The template previously developed for the Bank of Uganda was updated and a practical application of the CIEA for Uganda was shown. Mr. Hudson Bunya, economist at the Bank of Uganda, delivered a presentation on the approach taken by the Bank of Uganda to QGDP nowcasting using CIEA.

E. An Assessment of the Performance of the Current Forecasting Service

25. The MoFPED undertakes two forecasting exercises in a given fiscal year, using a sectoral approach based on interviews of businesses and line ministries. Real growth forecasts for 23 sectors of economic activity are aggregated to provide a forecast for real GDP. The main GDP forecast is done in late April–early May and serves a base for the budget of the coming fiscal year, starting in June. This growth forecast is then revised later in November, which is the month at which the budgetary process for the next fiscal year starts.

26. Table 2 contains a summary of forecasts and outturns since FY 2008–09. For instance, the real growth forecast for FY2012/13 was 5.4% in May 2012. This was revised downwards to 4.2% in November 2012 and upwards to 5.3% in May 2013. The outturn for FY 2012/13 was 5.8%.

Table 2. Uganda: Annual Forecasts for Real GDP Growth Rate (in %) Based on Sectoral Analysis

Forecast date	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14
May (t-1)	6.2	6.0	6.4	4.1	5.4	6.2
November (t)	7.4	6.0	6.3	5.0	4.2	5.7
May (t)	8.1	5.8	6.4	5.4	5.3	
Outturn	7.3	5.9	6.7	3.4	5.8	

27. **There is no systematic bias in the forecast published in May of the previous fiscal year and the mean absolute forecast error is small.** Over the period 2008–09 to 2012–13, the mean absolute error of the May forecasts for the next fiscal year is 0.52% (see Table 2), which is small relative to the average growth rate over the period (5.82%).

28. **Growth forecast revisions within the year do not increase the accuracy of the prevision (Table 3). Table 3** shows that the mean absolute errors of both the November and the May forecast are 0.74%, which are higher than the mean absolute error of 0.5% for the initial forecast. This is indicative of under-utilization of intra-year information.

Table 3. Uganda: Mean Absolute Error of Annual Forecasts

	May (t-1)	November (t)	May (t)
Mean Absolute Error	0.51%	0.76%	0.76%

IV. SUMMARY OF RESULTS

29. **One of the main results of the technical work implemented with the forecasting team of the MoFPED is that potential growth is probably between 6% and 6.5%, below the 7% that have been used so far in medium term exercise.** For potential growth to reach 7% the economy TFP growth would need to get back to the levels (2% per year) it had over the period 1990–2006. Another possibility for potential growth to reach 7% would be that oil production, which is to start in a near future, will increase the level of investment, hence the contribution of capital to economic growth. Our calculations have shown however, that a substantial increase in investment as a share of GDP (from 24% in 2012 to 30% by 2030) increases the annual potential growth rate only by 0.3%.

30. **As far as short term forecast are considered, work done during the mission has shown that there is room for improvement in the way growth forecasts are revised during the fiscal year.** The comparison between forecasts at different point in time during the year and outturn show that revised forecasts do not get closer to the outturn. A simple way to make forecast closer to outturn during the year is to use all available information at the time of the revision as the last two quarters of a fiscal year play little role in the outturn for growth of that fiscal year.

31. The ARIMA tool developed last year, and updated this year during the mission can provide initial forecast for the budget process. This tool can be updated and used every quarter as UBOS releases its real GDP estimates. For example, the GDP estimate for the second quarter of fiscal year 2013–14 was published by UBOS on April 1st, that same day the tool was used to forecast growth for the current fiscal year (6.0%) and that for next fiscal year (6.1%). Given the rapidity with which the tool can be updated and used it is a good starting point for forecasting the next year GDP growth, even if this tool is not yet accurate enough to be the main forecasting tool used at the MoFPED.

V. RECOMMENDATIONS AND NEXT STEPS

32. The mission found that, while MoFPED was equipped with a number of forecasting tools, it was not making full use of these tools. Recommendations were made on the steps necessary for computing five-year GDP forecasts, next year's GDP forecast, QGDP forecasts, and nowcasts. General recommendations were also made on how to improve modeling capacity at MoFPED

A. Five-Year GDP Forecasts

33. In the absence of a systematic basis for calculating potential output and hence a medium-term growth path for GDP, it is recommended that the methods of growth accounting be used. Calculations done during the mission has revealed that the current assumption of a constant seven percent real GDP growth for the next five years require strong underlying assumptions on the path of Total Factor Productivity (TFP) and growth of the capital stock.

34. Setting a sound basis for medium-term GDP forecasts is useful for two reasons:

a. It will facilitate the discussion likely to take place on the impact of the exploitation of natural resource on TFP, the accumulation of capital and the supply of labor.
b. It will enable more realistic projections of the five-year debt-to-GDP ratio. Keeping the present value of the debt-to-GDP ratio for the next five years within reasonable limits is an important requirement of the Public Financial management (PFM) Act and GDP forecasts as the denominator of this ratio needs to be as robust as possible.

In both cases, the growth accounting framework can be fruitfully used.

B. Next Year's GDP Forecast

35. The sectoral approach should be complemented with the ARIMA tool and forecast revisions should be systematically undertaken at each QGDP release. As additional data is added to the ARIMA model, its accuracy forecasting GDP in Uganda will improve, as additional data will be added to the tool. Also, forecast revisions for current and future fiscal years need to fully take into account the most recent real GDP estimates by UBOS. Finally, a systematic comparison of forecast and outturn need to be undertaken after each fiscal year, including an identification of the sources of forecast errors.

36. The MoFPED will have to update its forecasting tools and develop new ones as new data are made available by UBOS. During the course of this calendar year, UBOS will change the base year of national account from 2005 to 2010. The two tools that have been developed to forecast quarterly GDP will need to be updated when this data become available. It is difficult to say in advance the quantity of work these updates will require.

37. UBOS is also set to provide quarterly GDP decomposed by its expenditure elements. This demand-side decomposition could be used to develop short term forecasting tool to complement existing forecasting tools that rely exclusively on the supply side of the economy. For instance, the ARIMA modeling approach could be extended to the demand components of GDP. Error correction models on the main expenditure elements could be another possibility. The feasibility of these approaches will depend on the number of past observations that will be made available by UBOS.

C. Quarterly GDP Nowcasts and Forecasts

38. Given that QGDP is released with a four-month lag, there is scope to improve the nowcasts and forecasts of QGDP using Composite Indicators of Economics Activity (CIEA). Since the last AFE TA mission on CIEA in 2013, the Research and Statistics Department of BoU already produce CIEAs and have been very effective in maintaining the research agenda alive. Their research shows that a properly designed CIEA can be a very effective tool to understand the business cycle, which they indeed use as part of their briefs to the Monetary Policy Committee.

39. MoFPED has the option of using the CIEA that BoU publishes or of developing its own agenda. Both options have their pros and cons. Using BoU's CIEA would be less resource intensive but means that MoFPED may not be able to tailor the CIEA to its own needs—understandable, BoU needs real CIEAs to understand the potential real GDP, while the MoFPED may have an interest in nominal CIEAs to gauge trends in nominal tax and non-tax revenues.

D. General Recommendations

40. The authorities would be better off using economic models currently under construction sooner rather than later. The two economic models being developed by external consultants are designed to better inform policy makers regarding the impact of shocks and policies. The deployment of these models has been held up on the grounds that they have not reached their maturity. Discussions with the technical staff showed the advanced knowledge of some of them on these models. Based on this, it would be preferable to deploy these models for testing, with the usual caveats about the reliability of their results. It was felt that the wait for further refinements from consultants was excessively long and staff would benefit from learning-by-doing.

41. The reporting of the methodologies and the forecast errors of the different forecasting models need to be improved, more so given the exigencies of the Charter of Fiscal Responsibility of the forthcoming PFM Bill. The Charter will explicitly require macro-fiscal forecasts to be prudent and realistic and that they should be compared with those of other economic institutions. This will require that the assumptions behind the forecasts are made explicit. Additionally, the Charter will require that the reporting of forecast errors and their sources, and that forecasts based on alternative scenarios are made (that is, forecasts should not be restricted to baseline forecasts). All this will necessitate enhanced transparency.

Annex I. Uganda: The Production Approach to Measuring Total Factor Production and Potential Output

Assessing a projected growth path of real GDP against potential GDP growth is a useful exercise. Large and persistent deviations (positive or negative) of projected from potential growth signal some inconsistencies underlying the projections in the real sector.

The calculation of potential growth can be done using growth accounting. Output in the economy is assumed to be produced according to the following aggregate output function

$$Y = AK^{\alpha}L^{1-\alpha}$$

where Y is real GDP, K is the stock of capital, L is labor force and A is Total Factor Productivity (TFP), α is the share of income that goes to capital and (1-α) is the share of income that goes to labor.

Potential output as output that is compatible with the production function above. Any permanent shift in TFP, the capital stock and/or population will shift potential output. Thus, this methodology requires assumptions on the path of Total Factor Productivity (FTP), on labor force growth and investment (change in the capital stock). To support these assumptions, calculations from historical data are necessary. These are done in the following steps. We first need to find a measure of the capital stock for Uganda. In a second step, we compute the growth rate in total factor productivity over the past years. The third step consists in calculating potential growth for Uganda consistent with assumptions regarding investment in the future.

Step 1: Calculating the stock of capital for Uganda

Annual data are required for investment (which is the change in the capital stock), and real GDP. The IMF World Economic Outlook provides reliable data for Uganda GDP and share of investment in GDP for the period 1984–2012. Penn World table gives GDP and Investment starting in 1950.

We use data from the Penn World tables from 1950 to 1984 to calculate the ratio of capital to GDP in 1984 implementing a simple accumulation equation with an annual depreciation rate (α) of 5%, and with capital to GDP ratio equal to 2 in 1950. The capital to GDP ratio in 1984 is then 2.3

We can therefore calculate the stock of capital in 1985 using the following

$$K_{1985} = 2.3 \cdot GDP_{1984} + I_{1984} - \delta \cdot 2.3 \cdot GDP_{1984} \qquad \text{(A1)}$$

Further iterations of the above formula allow us to estimate the stock of capital until 2012. To check the robustness of our results, we assume a different initial capital to GDP ratio in 1950 and estimate the capital stocks for subsequent years. Table A1 shows the estimated growth of the stock of capital for Uganda for three different starting points of the capital stock to GDP ratio.

It is worth noting that the starting point chosen in 1950 has a small impact on the growth of capital over the period 1990–99 and almost none over the period 2000–12, as shown in Table A1. This justifies why data from 1950–84 was used to construct an initial capital-output ratio for 1984, date at which the IMF World Economic Outlook data for Ugandan GDP starts. The (easier) alternative would have been to make an assumption on the initial capital-output ratio for 1984 and deduce the growth of capital until 2012. Given the relatively short length of the time series (1984-2012) this approach would have made the growth in capital stock sensitive to the chosen initial condition for 1984.

Table A1. Uganda: Annual Growth (%) of the Capital Stock for Different Starting Point in 1950 for the Stock of Capital

	K1950 = **2** GDP1950	K1950 = **1** GDP1950	K1950 = **3** GDP1950
1990-1999	6.7	6.6	6.9
2000-2012	9.1	9.1	9.2

Step 2: Calculation of TFP and growth decomposition

From equation (1), we can deduce the growth rate of output to be

$$g_Y = g_A + \alpha g_K + (1 - \alpha) g_L \qquad \text{(A2)}$$

Knowing output, labor and capital growth and assuming a return to capital to GDP of 0.35, the growth in TFP can be deduced from equation (2). Table A2 below gives the growth decomposition for Uganda over the decade 1990–99 and 2000–12, and also within the later period over 2000–06 and 2006–12. There has been a slight slowdown in total factor productivity growth in Uganda over the period 2000–12 compare to that registered over the period 1990–99. This is entirely due to a drop in total factor productivity growth since 2007. Since 2007, the contribution to growth of total factor productivity has been less than 1% per year.

Table A2. Annual Growth Decomposition and Total Factor Productivity in Uganda
(In percentage terms)

	1990–99	**2000–12**	2000–06	2007–12
Real GDP growth	6.3	6.8	7.2	6.2
Contribution of Total Factor Productivity	*2.1*	*1.6*	*2.2*	*0.8*
Contribution of Labor	*1.9*	*2.0*	*1.8*	*2.3*
Contribution of Capital	*2.3*	*3.2*	*3.2*	*3.2*

Step 3: Calculating a potential growth using investment hypothesis in the medium and long term for Uganda

The idea is to combine TFP and labor force growth estimates over the medium term with hypothesis regarding real investment (public and private). Labor force growth is taken from ILO forecast for Uganda, two alternative hypothesis are considered for the share of investment in GDP: under the first hypothesis, the investment (I/Y) is constant (around 25%) at its observed value in 2012; under the second hypothesis, the investment rate increases regularly to reach 30%of GDP in 2030. Regarding TFP, 2 hypothesis are considered: a "low TFP growth" hypothesis where TFP grows at 1% per year, slightly above observed YFP growth over the period 2007-2012; a "high TFP growth" hypothesis where TFP growth is 2%, close to its value over the period 1990–99. Table A3 below gives Potential growth in Uganda combining different hypothesis.

Table A3. Four Scenarios for Potential Growth in Uganda (2013–23)

	Constant Investment Rate		Increasing Investment Rate	
	Low TFP growth	High TFP growth	Low TFP growth	High TFP growth
Real GDP growth	6.1	7.2	6.3	7.5
Contribution of Total Factor Productivity	1.0	2.0	1.0	2.0
Contribution of Labor	2.3	2.3	2.3	2.3
Contribution of Capital	2.8	2.9	3.0	3.2

Annex II. Uganda: Forecasting Using Autoregressive Moving Average

In October 2011, the Ugandan Bureau of Statistics (UBOS) started to publish quarterly estimates of real GDP based on the production approach. This was a significant improvement in the availability of timely data relating to the real sector. UBOS also continues to produce annual fiscal year and annual calendar year estimates of GDP, based on both the production and the expenditure approaches.

In addition, there is a requirement in government for more frequent estimates of nominal GDP, which are required as inputs into the IMF's macro framework. In March 2013, IMF East AFRITAC provided technical assistance to develop quarterly estimates of nominal GDP (production) together with a tool for forecasting these and real estimates of GDP.

The general approach to estimation is to 'reflate' the quarterly volume estimates for each of 23 activities within GDP production. In order to estimate quarterly deflators for each of these activities a monthly/quarterly Price Index was identified for each, which best represents the changes in prices for each activity. See Annex I for a list of the activities and the associated quarterly Price Index. However, the best estimate of the annual price change for each activity is provided by the annual GDP deflator for that activity. The estimation procedure therefore benchmarks the quarterly Price Indices to the annual deflators so that the 'path' of the resulting deflator follows the annual series. This is achieved using a constrained minimization of the squared differences between the original Price Index and the resulting quarterly deflators, with the constraint that the average of the resulting quarterly deflator is equal to the annual deflator in each year.

Once quarterly deflators have been created for each activity in this way, these are used to 'reflate' the quarterly volume GDP series to create a nominal series.

The quarterly series in both real and nominal terms can then be forecast using a standard ARIMA procedure (using the US Census Bureau's X12-ARIMA model).

The forecasts of GDP are based on ARIMA models for each of the 23 activities which comprise the aggregate for GDP at Market Prices (production measure). The procedure for calculating the models is the US Census Bureau's X12-ARIMA program. This has been built into the forecasting tool as an automated procedure, see later.

The specific ARIMA models can be selected by the user, but in most cases an 'automatic' selection by the X12 procedure itself is used. This allows the models to change, depending on the data, rather than requiring a full analysis of the models to be used each period.

To enable, each quarter, MEPD staff to run estimates of nominal GDP and forecasts of volume and nominal GDP, systems in MS Excel were developed by the mission. The systems provide:

- A user interface to select:
    a. Variables for inclusion in the GDP forecasts using simple ‘check-boxes;’
    b. The time period over which model estimation takes place;
    c. The reference period for the series;
    d. The ARIMA models associated with each sector of activity; or
    e. ‘An out-of-sample’ testing period
- The production of either a ‘volume’ or a ‘nominal’ GDP forecasts
- The facility to select to produce a GDP forecast based on the original, seasonally adjusted, trend-cycle or trend series.
- Built-in forecasting of the indicators using X12-ARIMA
- Estimation of the trend-cycle, the Hodrick-Prescott trend and the seasonally adjusted series
- The production of both quarterly aggregates as well as fiscal and calendar year series
- A summary ‘contributions analysis,’ showing the contribution of each activity in the GDP model to its annual growth.

Annex III. Background Information on the Composite Indicators of Economic Activity

This annex gives some background information on composite indicators, provide some of the steps necessary in its calculation and explain the competing methodologies.

Background

Indicators are pieces of information that summarize the characteristics of a system or highlight what is happening in a system. A mathematical of a set of indicators is most often called an "index" or a "composite indicator." Composite indicators are based on sub-indicators that have no common meaningful unit of measurement and there is no obvious way of weighting these sub-indicators for aggregation.

Usefulness: (1) Composite indicators can be used to summarize complex or multi-dimensional issues, in view of supporting decision-makers; (2) Composite indicators provide the big picture. They can be easier to interpret than trying to find a trend in many separate indicators; and (3) Composite indicators can help attracting public interest by providing a summary figure with which to compare the performance over time.

Limitations: (1) Composite indicators may send misleading, non-robust policy messages if they are poorly constructed or misinterpreted. Sensitivity analysis can be used to test for the robustness of the composite indicators; (2) the summarized picture provided by composite indicators may invite to draw simplistic policy conclusions. Composite indicators should be used in combination with the sub-indicators to draw more accurate policy conclusions; (3) the construction of composite indicators involves stages where judgment has to be made: the selection of sub-indicators, choices of methods or models, the weighting of sub indicators and the treatment of missing values and outliers; and (4) these judgments should be transparent and based on sound statistical principles.

Despite their limitations the composite indicators of economic activity provide experts and decision-makers with a valuable tool that allows them to: (1) monitor the trends and turning points of economic activity; (2) assess the trends in GDP in relation to goals and targets; (3) timely react to deviations from projections and adjust projections to changes in circumstances; (4) monitor fiscal and monetary policies on a more timely basis compared to quarterly and annual GDP changes and make the necessary adjustments; and (5) timely communicate the public and decision-makers about the performance of economic activity and changes in conditions and directions.

Since there is not a unique and objective method for developing a composite economic activity indicator that summarizes aggregate economic activity, it is crucial to ensure that the processes of constructing a composite indicator are as sound and transparent as possible.

Stages for the construction of composite economic activity indicators

The Organization for Economic Cooperation and Development (OECD) lists 10 steps/stages in the construction of composite indicators. The box below summarized these steps and provides the rationale for each.

Step	Why it is needed
1. Theoretical framework Provides the basis for the selection and combination of variables into a meaningful composite indicator under a fitness-for-purpose principle (involvement of experts and stakeholders is envisaged at this step).	• To get a clear understanding and definition of the multidimensional phenomenon to be measured. • To structure the various sub-groups of the phenomenon (if needed). • To compile a list of selection criteria for the underlying variables, e.g., input, output, process.
2. Data selection Should be based on the analytical soundness, measurability, country coverage, and relevance of the indicators to the phenomenon being measured and relationship to each other. The use of proxy variables should be considered when data are scarce (involvement of experts and stakeholders is envisaged at this step).	• To check the quality of the available indicators. To discuss the strengths and weaknesses of each selected indicator. To create a summary table on data characteristics, e.g., availability (across country, time), source, type (hard, soft or input, output, process).
3. Imputation of missing data Is needed in order to provide a complete dataset (e.g., by means of single or multiple imputation).	• To estimate missing values. • To provide a measure of the reliability of each imputed value, so as to assess the impact of the imputation on the composite indicator results. • To discuss the presence of outliers in the dataset.
4. Multivariate analysis Should be used to study the overall structure of the dataset, assess its suitability, and guide subsequent methodological choices (e.g., weighting, aggregation).	• To check the underlying structure of the data along the two main dimensions, namely individual indicators and countries (by means of suitable multivariate methods, e.g., principal components analysis, cluster analysis). • To identify groups of indicators or groups of countries that are statistically “similar” and provide an interpretation of the results. • To compare the statistically- determined structure of the data set to the theoretical framework and discuss possible differences.
5. Normalization Should be carried out to render the variables comparable.	• To select suitable normalization procedures that respect both the theoretical framework and the data properties. • To discuss the presence of outliers in the dataset as they may become unintended benchmarks. • To make scale adjustments, if necessary. • To transform highly skewed indicators, if necessary.

Step	Why it is needed
6. Weighting and aggregation Should be done along the lines of the underlying theoretical framework.	• To select appropriate weighting and aggregation procedure(s) that respect both the theoretical framework and the data properties. • To discuss whether correlation issues among indicators should be accounted for. • To discuss whether compensability among indicators should be allowed.
7. Uncertainty and sensitivity analysis Should be undertaken to assess the robustness of the composite indicator in terms of e.g., the mechanism for including or excluding an indicator, the normalization scheme, the imputation of missing data, the choice of weights, the aggregation method.	• To consider a multi-modeling approach to build the composite indicator, and if available, alternative conceptual scenarios for the selection of the underlying indicators. • To identify all possible sources of uncertainty in the development of the composite indicator and accompany the composite scores and ranks with uncertainty bounds. • To conduct sensitivity analysis of the inference (assumptions) and determine what sources of uncertainty are more influential in the scores and/or ranks.
8. Back to the data Is needed to reveal the main drivers for an overall good or bad performance. Transparency is primordial to good analysis and policymaking.	• To profile country performance at the indicator level so as to reveal what is driving the composite indicator results. • To check for correlation and causality (if possible). • To identify if the composite indicator results are overly dominated by few indicators and to explain the relative importance of the sub-components of the composite indicator.
9. Links to other indicators Should be made to correlate the composite indicator (or its dimensions) with existing (simple or composite) indicators as well as to identify linkages through regressions.	• To correlate the composite indicator with other relevant measures, taking into consideration the results of sensitivity analysis. • To develop data-driven narratives based on the results.
10. Visualization of the results Should receive proper attention, given that the visualization can influence (or help to enhance) interpretability	• To identify a coherent set of presentational tools for the targeted audience. • To select the visualization technique that communicates the most information. • To present the composite indicator results in a clear and accurate manner.

Alternative Methodologies:

There are two types of Methodologies: Accounting and Statistical Methodologies.

Accounting Methodologies:

This type of methodologies tries to replicate the methodology used for the compilation of the quarterly and annual GDP. Sectoral indicators are associated with the sectoral classification of economic activities used to compile the quarterly GDP at constant prices or current prices. The weights are the same as those used for the compilation of the quarterly GDP.

This type of methodology is feasible and makes sense in a context of a sufficiently developed statistical system, which provides an ample availability of sectoral sub indicators which can be associated and are closely related to the compilation of quarterly and annual GDP.

Statistical Methodologies:

1. The Conference Board:

In 1995, the Conference Board assumed responsibility for computing composite indexes from the US. The Conference Board now produces business cycles indexes for the US, Australia, France, German, Korea, Japan, Mexico, and the UK.

Methodology:

The construction of the CEIA is done in the following five steps.

Step 1: Calculate the symmetric percent change $r_i(t)$

$$r_i(t) = 100 \frac{y_i(t) - y_i(t-1)}{\left[y_i(t) + y_i(t-1)\right] / 2}$$

where $y_i(t)$ is the observation at time *t* for the indicator *i*.

if the given time series is zero or a negative value, or is already in percentage form, simple arithmetic differences are calculated. $r_i(t) = y_i(t) - y_i(t-1)$.

<u>Motivation</u>: the reason for calculating the symmetric changes is to allow these to be weighted together (steps 2-3) in such w way that the positive and negative growth are treated equally. With the symmetric growth rate a rise of 50%, followed by a fall of 50% returns to the initial value. With a normal growth rate, i.e., $r_i(t) = 100 \frac{y_i(t) - y_i(t-1)}{y_i(t-1)}$, this is not the case.

The symmetric growth is best thought of as using the average of the start and end periods over which the growth is being measured. With the normal growth rate formula, it is just the starting point (i.e., $y_i(t-1)$) that is used as the reference period for the calculated growth.

Step 2: Calculate a 'weight' for each indicator based on the inverse of the standard deviation of the symmetric changes of each series, i.e.

$$w_i = \frac{1}{\sqrt{\frac{\sum_t \left(r_i(t) - \bar{r}_i(t)\right)^2}{n-1}}}$$

<u>Motivation</u>: This choice of weights gives less volatile series greater weight and more volatile series less weight. In this way the contributions from each series to the change in the aggregate index are ‘equivalent’, in the sense that the weight multiplied by the (symmetric) change from each series are equal on average over the time period for which the CEIA is calculated.

Step 3: Weight the symmetric percent changes together:

$$r(t)=\sum_i w_i r_i(t)$$

Step 4: Invert the symmetric percentage change to calculate the CIEA:

i.e., since $r(t)=200\frac{y(t)-y(t-1)}{y(t)+y(t-1)}$, we have

$$r(t)y(t)+r(t)y(t-1)=200y(t)-200y(t-1)$$

So that

$$200y(t-1)+r(t)y(t-1)=200y(t)-r(t)y(t)$$

$$y(t)=y(t-1)\frac{200+r(t)}{200-r(t)}$$

Note the initial starting point for the series can be set arbitrarily equal to 1, to ensure the index covers the full-time period covered by the indicators themselves.

Motivation: this step is required to move back into ‘index level space’, rather than (symmetric) parentage change space. Note that once back in index level space it is correct to calculate percentage changes from the index in the usual way (i.e. it is not necessary to calculate percentage changes using the symmetric formula, which was simply a device to all the weighting together of the changes of each indictor into a composite index).

Step 5: Re-reference the index so that the average of the reference period is equal to 100.

Motivation: this step is only required for presentational purposes, so that the CIEA is presented in a traditional index form with some period set equal to 100.

2. The Moore-Shiskin methodology:

It is derived mainly from the conference Board Methodology with some slight modifications. This methodology was developed by the US National Bureau of Economic Research (NBER) and later by Foundation for International Business and Economic Research, Inc. The basic difference between the Moore-Shiskin methodology and that of the Conference Board is that the series is adjusted for seasonality factors before applying the necessary steps.

Methodology:

1. Estimation of seasonal factors for each component series.
2. For nominal variables, the series is deflated using appropriate seasonally adjusted price deflators to reflect real activities.

3. Month-to-Month symmetric percentage changes for each adjusted component are computed.
4. The month-to-month changes are standardized using mean absolute deviation of the changes (to equalize the volatility of each component).
5. The index's symmetric percentage change is then computed as the average of the components' standardized changes.
6. The level of the index is computed using the symmetric percentage change formula and rebased to average 100 in a chosen year.

3. Roberto Tibana (OECD Development Center, 2003):

This methodology applies the Henderson moving average as opposed to the simple moving average in deriving the seasonal factors. The Hodrick-Prescott Filter is then applied to derive cyclical components of the constructed index.

Methodology:

1. The data is converted from its original units into index numbers to reduce all variables to similar scale of measurements.
2. Seasonal adjustment, treatment of outliers, separation of the irregular component from the seasonally adjusted series, and the derivation of the trend-cycle series of each of the individual variable is estimated using a Henderson Moving Average methodology. Henderson moving average is a non-simple moving average, where the weights are not the same for all items).
3. Aggregation of the individual trend-cycle series into a composite trend-cycle indicator:
    a. One procedure consists in deriving "sub-sector" trend-cycle series using a simple average procedure. These are then aggregated into an overall trend-cycle composite indicator using weights derived from GDP shares of the sectors of the economy represented by those sub-sector composite indicators.
    b. Another procedure consists in applying principal component analysis (PCA) on the original trend-cycle series to derive the weights used to aggregate them into the trend-cycle composite indicator.
4. Computation of the cyclical Composite Indicator of Economic Activity is done via the following two steps: (a) obtaining the composite trend (T) component of the composite trend-cycle (TC) series constructed in step 3 above. This is achieved through the Hodrick-Prescott filtering Technique (b) The aggregated cyclical component is derived as a ratio of the Henderson Moving Average over the derived Hodrick-Prescott trend.

4. Economic and Social Research Institute, Cabinet Office, government of Japan

See http://www.esri.cao.go.jp/en/stat/di/di2e.html for a motivation for this method.

In this variant of the standard US Conference Board methodology, the composite indexes are calculated by composing month-to-month percentage changes in multiple economic indicators. As a simplified example, assume that one of the composite indexes is constructed from two indicators, Indicator A and Indicator B ("y1" and "y2" in the illustration below). In a certain month, Indicators A and B are higher than the previous month by 1 percent and 0.5 percent respectively ("γ1" and "γ2" in the same illustration). These change rates are averaged, and the average is multiplied by the previous month's level of the composite index to obtain the current month's.

The change rates with different volatilities are subjected to a process called "normalization" before averaging so that they can be evaluated on a common basis. Assume a situation in which Indicator A shows an upward trend and large monthly fluctuations, while Indicator B shows a flat trend and small monthly fluctuations. In this situation, the change rates have different meanings between Indicator A and B.

The normalization process is performed taking into consideration two types of elements: trend and amplitude. Assume that Indicator A has a trend of 2 percent and an amplitude of 0.5 percent, the normalized percentage change rate for Indicators A is calculated as follows:

(Change rate for the current month 1 - Trend 2) / (Amplitude 0.5) = -2.

Similarly, assume that Indicator B has a trend of 0 percent and an amplitude of 0.2 percent, the normalized percentage change rate for Indicator B is calculated as follows:

(Change rate for the current month 0.5 - Trend 0) / (Amplitude 0.2) =2.5.

Then, the "composite normalized percentage change rate," Z, is calculated as follows, by averaging the normalized percentage change rates of Indicators A and B:

$Z = (-2 + 2.5) / 2 = 0.25$.

Because Z is an absolute number with no dimension, it should be adjusted back to the percentage change of the original economic indicators by taking the following two steps: (1) the composite normalized percentage change Z is multiplied by the composite amplitude σ, which is obtained by averaging the amplitudes of Indicator A and B; and (2) the composite trend μ is added to the result of step (1). The result of the two steps represents the composite "month to month percentage change " V. Then, the current month's composite index is obtained by multiplying V by the previous month's level of the composite index. Individual indicators' month-to-month percent change rate is calculated using a "symmetric percentage change." The symmetric percentage change uses for the denominator an average of the previous and current month values (mean value), instead of the previous month's level, as in the ordinary calculation of month-to-month ratios. When calculating, the composite index based on V, the symmetric percentage change formula is used inversely.

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